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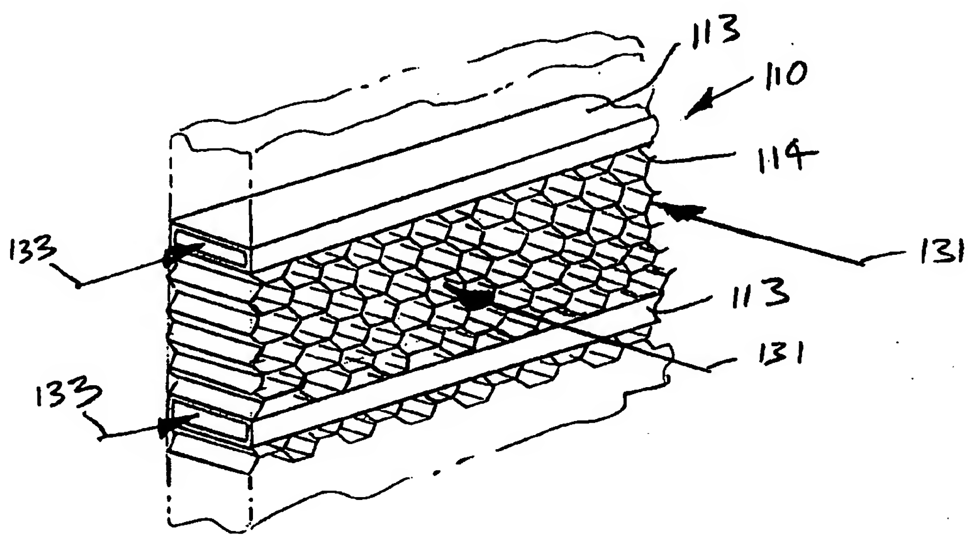

(57) Abstract

A heat exchanger (110) comprised of a plurality of tubes (113) and a hexagonal channel fin structure (114).

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TITLE OF THE INVENTION

Heat Exchanger With Hexagonal Fin Structure and Method Of Making Same

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/087,014, filed May 28, 1998.

BACKGROUND OF THE INVENTION

Heat exchangers are used in many applications, such as automobile radiators as well as for residential and commercial heating, ventilation and air conditioning systems. Typically, a heat exchanger includes a plurality of heat exchange tubes which are adapted to carry a first fluid media from which heat is to be transferred. The heat exchange tubes are typically arranged in a fin structure, and the fins are generally in positive contact with the outside of the tubes. A second fluid media to which the heat is to be transferred is passed through the fins to remove heat which is transferred from the first fluid media, through the tubes and into the fin structure. Similar structures can also be used for the transfer of mass or energy, however, as used herein "heat exchanger" is intended to refer to an energy or mass exchange device as described.

Several factors influence the heat transfer efficiency of a heat exchanger. These include the number of tubes in the heat exchanger, the contact area between the fins and tubes, the surface areas of the flow passage surfaces located on the tubes, the selection of materials, and the mass flow rate of the first and second fluid media through the heat exchanger, among others.

Additionally, the pressure drop across the depth of the heat exchanger can also influence the overall system efficiency, since a higher pressure drop requires more power to maintain a desired mass flow rate through the heat exchanger.

In order to provide an optimized flow for fluid through the fins which surround the tubes which carry the first fluid media, it would be desirable to provide as large an effective surface area for the fins as possible per unit volume, while at the same time minimizing the pressure drop in the fluid flow across the fins.

SUMMARY OF THE INVENTION

Briefly stated, the present invention provides a heat exchanger having a plurality of tubes adapted to receive a flow of a first fluid medium. A fin structure is provided through which the plurality of tubes extend. The fin structure is adapted to receive a flow of a second fluid medium for mass or energy transfer. The fin structure includes a plurality of adjacent hexagonal channels which extend generally transversely to the plurality of tubes. The plurality of tubes are in heat conducting contact with the fin structure.

In another aspect, the present invention provides a method of forming a heat exchanger with a hexagonal fin structure. The method includes:

providing a plurality of layers of sheet material, with each layer of sheet material having a plurality of spaced apart adhesive lines;

indexing and stacking the layers of sheet material such that the adhesive lines on adjacent sheets are staggered;

providing aligned openings in the layers of sheet material at desired tube locations;

curing the spaced apart adhesive lines to form an unexpanded core block;

placing tubes in the aligned openings;

expanding the unexpanded core block over the tubes to form the heat exchanger with the hexagonal fin structure.

In another aspect, the invention provides a method of forming a heat exchanger with a hexagonal fin structure. The method includes:

providing a plurality of layers of sheet material, with each layer of sheet material having a plurality of spaced apart adhesive lines;

indexing and stacking the layers of sheet material such that the adhesive lines on adjacent sheets are staggered;

placing tubes at desired locations within the stacked layers of sheet material between layers of sheet material;

curing the spaced apart adhesive lines to form an unexpanded core block with the tubes in the desired locations within the core block; and

expanding the unexpanded core block to form the heat exchanger with an expansion formed hexagonal fin structure located between adjacent tubes.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of the preferred embodiments of the invention, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the

drawings embodiments which are presently preferred. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

In the drawings:

Fig. 1 is a perspective view, partially cut away at lines X and Z, illustrating a heat exchanger constructed with a hexagonal fin structure in accordance with the present invention;

Fig. 2a is a cross-sectional view taken along lines 2-2 in Fig. 1;

Fig. 2b is a cross-sectional view similar to Fig. 2a in which the orientation of the flow channels relative to the tubes is changed;

Fig. 3 is a perspective view of a strip of material used for assembling the core;

Fig. 4 is a perspective view of an unexpanded core block with heat exchanger tubes located in the openings in the core block, prior to expansion of the core block;

Fig. 5 is a perspective view, partially broken away, of a piece of expanded core which has been coated with a catalyst;

Fig. 6 is a plan view of a multi-row heat exchanger in accordance with the present invention in which the hexagonal fin structure in each row is different;

Fig. 7 is a plan view of a multi-row heat exchanger in accordance with the present invention similar to Fig. 6 in which each row is spaced apart from the adjacent row and includes different hexagonal fin structure and/or tubing in the different rows;

Fig. 8 is a perspective view of an unexpanded core block similar to Fig. 4 which includes spaced apart tubes incorporated in the core block;

Fig. 9 is a perspective view similar to Fig. 8 in which the unexpanded core block has been expanded to form a heat exchanger having a hexagonal fin structure in accordance with another embodiment of the invention; and

Fig. 10 is a plan view of a heat exchanger similar to that shown in Fig. 9 in which the strips of material used to form the unexpanded core block and the tubes incorporated in the core block have a profiled contour.

DETAILED DESCRIPTION OF THE INVENTION

Certain terminology is used in the following description for convenience only and is not limiting. The words "right," "left," "lower," and "upper" designates directions in the drawings to which reference is made. The words "inwardly" and "outwardly" prefer to directions toward and away from, respectively, the geometric center of the heat exchangers with hexagonal fins in accordance with the present invention, and designated parts thereof. The terminology includes the words noted above as wells as deviates thereof and words of similar import.

Referring to the drawings, where like numerals indicate like elements throughout, there is shown in Figs. 1 and 2a, a heat exchanger 10 in accordance with the present invention. As noted above, the heat exchanger 10 is intended to refer to a construction that can be used for energy or mass transfer, and is not intended to be limited to only heat transfer. However, for the sake of convenience, the present invention has been described in terms of a heat exchanger although the identical structure could be used for energy and mass transfer.

The heat exchanger 10 includes tubes 12a, 12b, and 12c and a fin structure 14 located around the tubes 12a, 12b, and 12c. Preferably the tubes 12a, 12b, 12c are seamless

drawn copper tubes which are adapted to be mechanically expanded to provide a positive fin/core 14 to tube 12a-c contact to provide a high heat transfer efficiency and long life. However, it will be recognized by those skilled in the art from the present disclosure that tubes made of other materials may be used, and that the tubes need not be expanded and can be joined with the fins through other means such as soldering or brazing or other suitable means. Preferably, the tubes, 12a, 12b, and 12c are connected to inlet and outlet manifolds for passing a first fluid medium through the tubes. Alternatively, the tubes may be connected together in series using couplings between the ends of the adjacent tubes. The tubes 12a, 12b, 12c are preferably circular in cross-section, but may have any other desirable cross-section, such as an elliptical, oval or polygonal cross-section.

As shown in detail in Figs. 1 and 5, preferably the fin structure 14 comprises a plurality of adjoining hexagonal channels 16. The hexagonal channels 16 are formed from stacked layers of sheet material 18, as shown in figures 3 and 4, which are assembled together using spaced apart adhesive lines 20 which are cured to form a core block 22. The adhesive is preferably a heat setting epoxy adhesive, but can be any other suitable adhesive material, such as a brazing compound or welding. Preferably, a plurality of holes 24 are punched through the sheet material 18 at the tube locations prior to assembling the layers of sheet material 18 into the core block 22. The layers of sheet material 18 are indexed such that the holes 24 are aligned and the glue lines on adjacent sheets 18 are staggered. The holes 24 are formed with the an oblong shape in the flat sheet material 18 such that after curing of the adhesive and upon expansion of the core block 22, a generally circular opening for receiving each of the tubes 12a-c is formed. However, the holes 24 can be cut, punched, drilled or formed by any other suitable means, such

as laser or water jet cutting. The holes 24 may also be of other shapes to conform to other tube geometries, if desired.

Preferably, the sheet material comprises a metallic material, such as aluminum or copper. However, any other suitable metallic or non-metallic materials may be used. The sheet material is preferably between 0.0005 to 0.02 inches in thickness. However, any thickness can be utilized, depending upon the material selected. It will be recognized by those skilled in the art from the present disclosure that the adhesive lines may be applied by various methods, such as printing glue lines on the sheet material 18. The layers of sheet material 18 are preferably placed in a sheeter stacker apparatus which indexes the sheets 18 to form the uncured core block 22. However, the uncured core block 22 may be laid up by other means, such as manually. The stacked layers of sheet material 18 are then preferably subjected to heat and/or pressure to activate the adhesive lines 20. However, it will be recognized for those skilled in the art from the present disclosure that other suitable adhesives or connecting agents may be used to form the adhesive lines 20, as discussed above, such as chemical bonding agents or adhesives, brazing material that is heat activated or welding material, and other types of curing or activating means can be used for the adhesive system or connecting agents can be utilized, depending upon the materials. It will also be recognized by those skilled in the art that the holes 24 could also be omitted from the sheets 18, and formed in the unexpanded core block 22.

After the core block 22 has been cured, the tubes 12a, 12b, and 12c are placed in the core block through the holes 24. The core block 22 is then expanded in the known manner in the direction of arrows 28 and 30 in Fig. 4 to form the expanded core. As previously noted, during the expansion process the holes 24 form openings which conform to the shape of the

outside of the tubes 12a, 12b and 12c to provide some contact for heat transfer. If desired, the tubes 12a, 12b, 12c can be expanded as previously noted in order to provide more intimate fin surface to tube contact between the fin structure 14 and the tubes 12a, 12b, 12c for improved heat transferred efficiency. Alternatively, a separate process can be used to provide sufficient contact between the tubes 12 and the fins 14 for heat transfer, such as soldering, brazing or any other suitable adhering or coating process which allows or promotes heat transfer without the need for mechanical tube expansion.

Referring now to Fig. 5, a partial section of the expanded core is shown in which the layers of expanded sheet material 18 are clearly illustrated. As shown, each hexagonal cell of the hexagonal fin structure 14 has four sides formed from a single layer or thickness of the sheet material 18, and two sides formed from a double layer of the sheet material 18 in the area of the adhesive lines 20. Additionally, the core segment shown in Fig. 5 has been coated with a coating material 26. The coating 26 may be a material useful for the catalysis of pollutants, such as the conversion of CO to CO_2. However, the coating 26 is optional and need not be provided. Preferably, the coating material is a catalyst such as PREMAIR™ which is available from Engelhard Corporation and which acts as a catalyst for converting O_3 to O_2 and/or CO to CO_2. Alternatively, a hopcalite material or any other suitable catalytic material may be used. The coating 26 of catalytic material may be provided on both the hexagonal fin structure 14 and the tubes 12a, 12b, 12c, or only one surface alone, such as either the hexagonal fin structure 14 or the tubes 12a, 12b, 12c, if desired. The coating 26 may also be in the form of a liquid desiccant material sprayed onto the surface of the hexagonal fin structure 14.

It will be recognized by those skilled in the art from the present disclosure that the materials utilized for fabricating the tubes 12a, 12b and 12c as well as the sheets 18 may be any suitable or desirable material or combination of materials, such as cellulose, metals, plastics, and other man-made or refined naturally occurring earth type materials.

Referring now to Fig. 2b, an alternate embodiment of the heat exchanger 10' is shown in which the channels 16 are oriented at an angle θ relative to the tubes 12a-c. This provides for an increased surface area of the fins 14 within the same depth. It will be recognized by those skilled in the art from the present disclosure that the channels 16 of the fin structure 14 can be oriented in any desired angle or manner for optimal energy exchange, or to suit a particular application, and that no specific orientation is required.

The use of channels 16 having a cross-section which is generally in the form of a hexagon is advantageous over the prior art geometries. First, the theoretical transfer surface area of a hexagon is greater than the transfer surface area of a sinusoidal, triangular, square or rectangular shaped channel for a given volume. Additionally, hexagonal channels 16 provide a reduced pressure drop across the fin structure. Therefore, the power necessary to move a fluid media through the fin structure is significantly less than that needed to force the fluid media through the prior known fin structures.

Referring now to Fig. 6, a heat exchanger assembly 50 having multiple rows is shown. Each row comprises a heat exchanger 10', 10" similar to the heat exchanger 10 described above. The heat exchangers 10', 10" can have different hexagonal passage sizes and core depths, and the sizes of the tubes 12', 12" can be varied. The tubes 12', 12" can be connected together in series or in parallel through the use of inlet and outlet manifolds (not shown). Therefore, it will

be recognized by the skilled artisan that a heat exchanger assembly 50 can be formed using multiple rows of tubes 12', 12", with each row of tubes 12', 12" being surrounded by a fin structure 14', 14" having channels 16 of the same or different sizes. For example, a first row of tubes can be located in the fin structure 14' having channels 16 of reduced size, such as 0.125 inches, and a second row of tubes 12" can be located in the second fin structure 14" having 0.25 inch channels 16', such that the pressure drop of the fluid media flowing through the stacked fin structure is minimized.

As shown in Fig. 7, a heat exchanger assembly 60 can also be provided which includes multiple rows, with each row comprising a heat exchanger 10', 10", 10'" similar to the heat exchanger 10 described above. The heat exchangers 10', 10", 10'" can have different hexagonal passage sizes, core depths, and angled flow passages combined with the horizontal flow passages. The sizes of the tubes 12', 12", 12'" can also be varied. The heat exchangers 10', 10", 10'" are spaced apart from each other to prevent equalization of the temperature across the hexagonal fin structures 14', 14", 14'". These arrangements allow an efficient means of staging with minimal controls for heat and mass transfer applications, such as refrigeration condensers, subcoolers and evaporators.

Referring now to Figs. 8 and 9, a second embodiment of a heat exchanger 110 with a hexagonal fin structure 114 is shown. Tubes 113 are incorporated into the hexagonal fin structure 114 during assembly of the core block 122 (shown in Fig. 8) used to form the hexagonal fin structure. Preferably the tubes 113 have a flattened profile and are incorporated with the layers of sheet material 118 utilized to form the core block 122. The sheet material 118 includes spaced apart adhesive lines in a similar manner to the sheet material 18 in accordance

with the first embodiment of the invention 10, as discussed above. Adhesive lines may also be applied to the tubes 113. Preferably, the tubes 113 are provided with the final desired profile and do not expand in size during the formation of the hexagonal fin structure 114. However, it will be understood by those skilled in the art from the present invention that the material that forms the tubes 113 can be provided in a closed configuration such that the tube cross-sectional area also expands as the core block 122 is expanded to form the desired open tube configuration at the same time as the hexagonal fin structure 114 is formed.

After the core block 122 which incorporates the tubes 113 is stacked, the adhesive lines, which are preferably a heat activated epoxy as discussed above, are cured to form a cured core block 122. The cured core block 122 is then expanded in order to form the hexagonal fin structure 114, as shown in Fig. 9. A first fluid media, represented by arrows 131 can be passed through the tubes 113, and a second fluid media, represented by arrows 133, can be passed through the hexagonal fin structure 114 for heat or mass transfer. As noted above in connection with the first embodiment 10, the hexagonal fin structure 114 and/or the tubes 113 may be coated with a catalytic material. The tubes 122 may be connected to inlet and outlet headers (not shown) on either side of the heat exchanger 110, or can be connected together in series with auxiliary pipes.

Referring now to Fig. 10, a top plan view of a heat exchanger 110' which is constructed in a similar manner to the 110 is shown. The heat exchanger 110' is formed with a profiled contour in order to provide a heat exchanger 110' that can fit into profiled spaces. The sheet material 118' and the tubes 113' are precut or formed to the desired shape prior to being assembled into the core block and expanded. The hexagonal fin structure 114 is maintained in a

parallel configuration, generally normal to the flow of the fluid medium 133 through the tubes 113' in order to maintain a high efficiency, low head loss flow through the heat exchanger 110'.

It will be recognized by those skilled in the art that such an arrangement also allows for three-dimensional profiling by offsetting the layers of sheet material 118' as they are stacked, or by providing an oversize sheet material 118' which is stacked with tubes having the desired contours that are appropriately offset in the core block, such that after expansion of the core block to form the hexagonal fin structure 114', the tubes 113' are in the proper position. The excess sheet material used to form the hexagonal fin structure 114' can then be machined or cut away to form the desired three-dimensional contour of the fin structure 114' around the tubes.

It will be similarly be recognized that a flexible honeycomb core could be formed to a desired contour and then stabilized in the desired contour position through the use of an adhesive system, such as a heat setting epoxy, or through other known means for stabilizing flexible honeycomb core. Holes for the tubes could then be formed through the stabilized core and the tubes inserted and expanded, or otherwise connected to the core in a thermally conductive manner. However, the hexagonal fin structure would include hexagonal cells which, depending upon the profile or contour, would not be parallel to each other over the entire area of the fin structure, which would likely increase the pressure drop across the depth of the heat exchanger thus formed.

While in the preferred embodiment the fin structure 14, 114 is formed from an expanded core block, it is within the scope of the present invention to provide a fin structure 14, 114 having hexagonal channels made by other means, such as by machining, assembling

individually formed channel pieces having a hexagonal cross-section, or any other known method. the holes 24 for the tubes 12 can be formed by a separate operation.

It will be understood be those skilled in the art from the present disclosure that the number of tubes 12a-12c, 12', 12", 12''' may be varied, and that multiple rows of tubes may be provided in the fin structure 14. Additionally, the size of the hexagonal channels 16 may be varied to suit different applications. Preferably, the hexagonal channels 16 are up to 1.0 inch in size.

In operation, fluids in the form of liquids or gasses may be passed through the channels 16 as the secondary fluid. Liquids may also be deposited onto the core or fin structure 14, 114 through various methods, such as spraying, intermittent, timed or continuous misting, or by other means for the purpose of promoting and/or effecting a change in mass, heat, catalysis, or phase, or any combination thereof to the secondary fluid.

It will be appreciated by those skilled in the art that changes can be made to the embodiments of the invention described above without departing from the broad inventive concept of providing a heat exchanger having a hexagonal fin structure for improved heat transfer efficiency between fluid streams, as well as providing the possibility of placing a catalytic coating or other type of coating on the fin structure. It is understood, therefore, that the present invention is not limited to the specific embodiments described, but is intended to cover other embodiments within the spirit and scope of the present invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. A heat exchanger comprising:

a plurality of tubes adapted to receive a flow of a first fluid medium;

a fin structure through which the plurality of tubes extends, the fin structure being adapted to receive a flow of a second fluid medium for mass or energy transfer; and

the fin structure comprising a plurality of adjacent hexagonal channels which extend generally transversely to the plurality of tubes, the plurality of tubes are in heat conducting contact with the fin structure.

2. The heat exchanger of claim 1 wherein the hexagonal channels are formed from layers of sheet material.

3. The heat exchanger of claim 2 wherein the layers of sheet material are stacked and assembled together using spaced apart adhesive lines to form a core block.

4. The heat exchanger of claim 3 wherein a plurality of holes for receiving the tubes are punched through the sheets of material at tube locations prior to expansion of the core block to form the hexagonal channels.

5. The heat exchanger of claim 4 wherein the plurality of tubes are located in the holes and are mechanically expanded to provide a positive fin structure to tube with a high heat transfer efficiency.

6. The heat exchanger of claim 3 wherein the tubes are located between layers of sheet material in the stacked layers of sheet material.

7. The heat exchanger of claim 2 wherein the sheet material is between 0.0005 to 0.02 inches in thickness.

8. The heat exchanger of claim 1 wherein a coating of a catalytic material is located on the hexagonal channels.

9. The heat exchanger of claim 1 wherein a coating of a desiccant material is located on the hexagonal channels.

10. The heat exchanger of claim 1 wherein the heat exchanger includes a plurality of hexagonal fin structures which are spaced apart in a flow direction, at least one of the plurality of hexagonal fin structures having a different fin structure parameter than the remaining hexagonal fin structures.

11. The heat exchanger of claim 1 wherein the hexagonal channels are oriented at an angle of less than 90° relative to the tubes.

12. A method of forming a heat exchanger with a hexagonal fin structure comprising:

providing a plurality of layers of sheet material, with each layer of sheet material having a plurality of spaced apart adhesive lines;

indexing and stacking the layers of sheet material such that the adhesive lines on adjacent sheets are staggered;

providing aligned openings in the layers of sheet material at desired tube locations;

curing the spaced apart adhesive lines to form an unexpanded core block;

placing tubes in the aligned openings;

expanding the unexpanded core block over the tubes to form the heat exchanger with the hexagonal fin structure.

13. The method of claim 12, wherein the aligned openings are provided by punching holes through the layers of sheet material at the tube locations prior to assembling the sheets of material into the core block.

14. The method of claim 13, further comprising forming the holes with an oblong shape in the sheet material and such that upon expansion of the core block one of a generally circular or polygonal opening is formed.

15. The method of claim 12, wherein the indexing and stacking of the layers of sheet material further comprises placing the layers of sheet material in a sheeter stacker which indexes and stacks the sheet material to form the core block.

16. The method of claim 12, wherein the curing of the adhesive lines further comprises applying heat and pressure to activate the adhesive lines.

17. The method of claim 12, further comprising expanding the tubes after the core block is expanded in order to provide more intimate tube contact between the hexagonal fin structure and the tubes for improved heat transferred efficiency.

18. The method of claim 12, further comprising coating the hexagonal fin structure with a catalytic material.

19. The method of claim 12, further comprising coating the hexagonal fin structure with a desiccant material.

20. A method of forming a heat exchanger with a hexagonal fin structure comprising:

providing a plurality of layers of sheet material, with each layer of sheet material having a plurality of spaced apart adhesive lines;

indexing and stacking the layers of sheet material such that the adhesive lines on adjacent sheets are staggered;

placing tubes at desired locations within the stacked layers of sheet material between adjacent layers of sheet material;

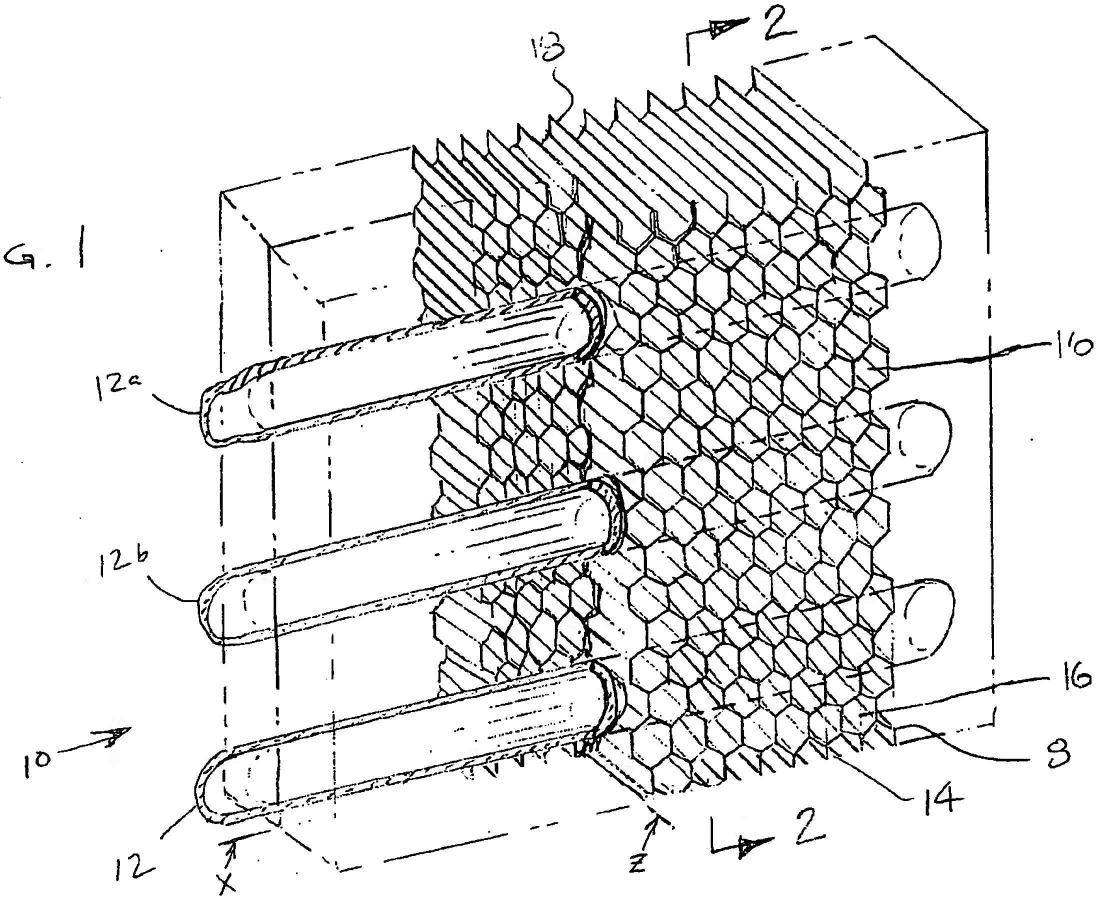
curing the spaced apart adhesive lines to form an unexpanded core block with the tubes in the desired locations within the core block; and

expanding the unexpanded core block to form the heat exchanger with an expansion formed hexagonal fin structure located between adjacent tubes.

21. The method of claim 20 further comprising providing the layers of sheet material and the tubes with a contour to form a contoured heat exchanger.

22. The method of claim 20, further comprising coating at least one of the hexagonal fin structure and the tubes with a catalytic material.

Fig. 1



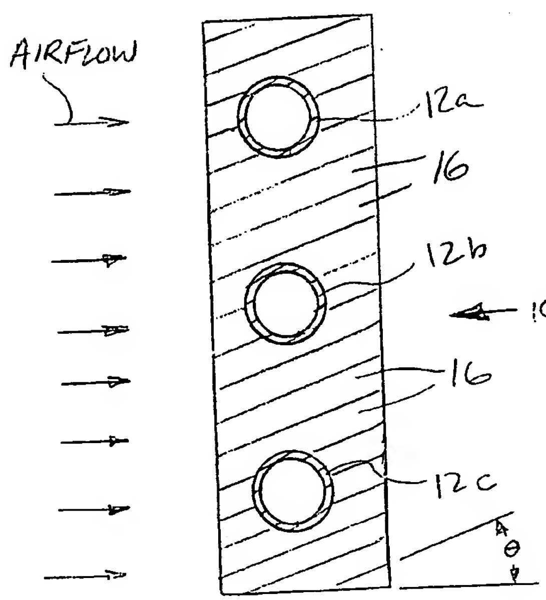


Fig. 2b

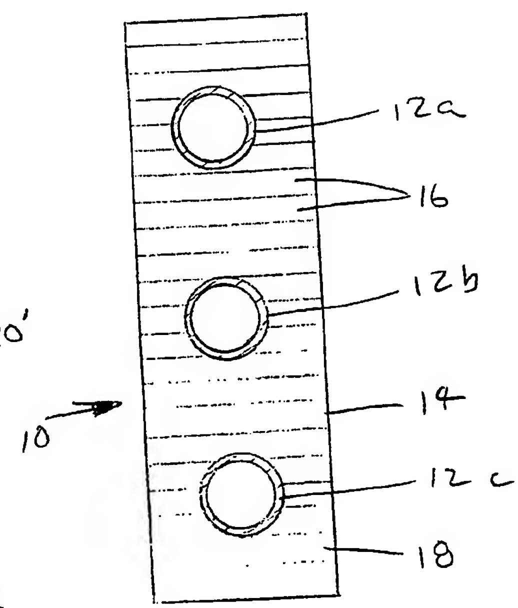


Fig. 2a

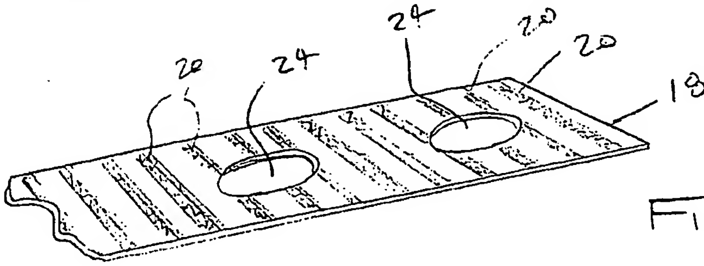


FIG. 3

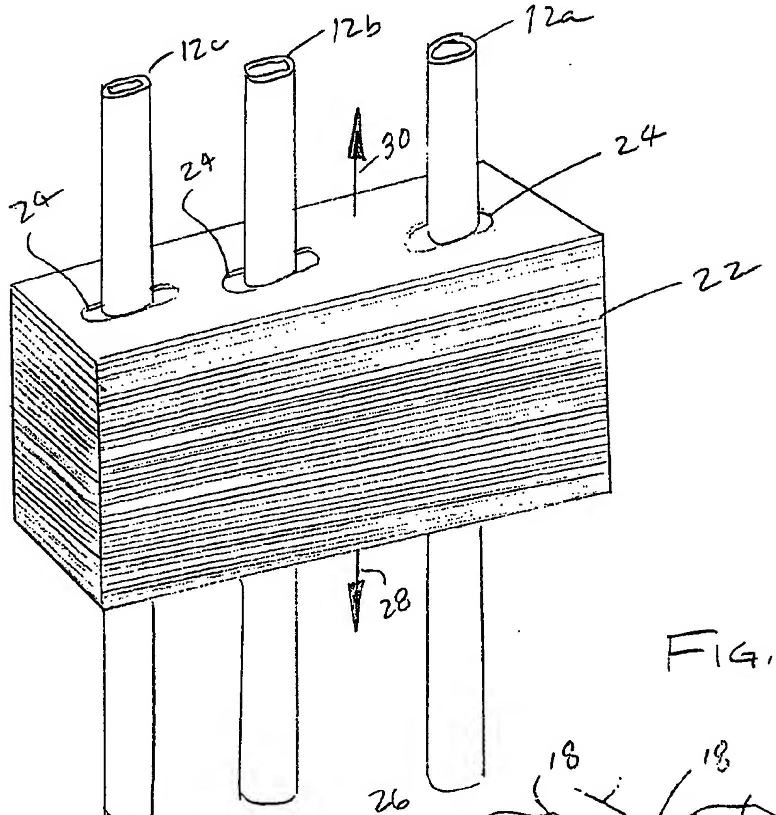


FIG. 4

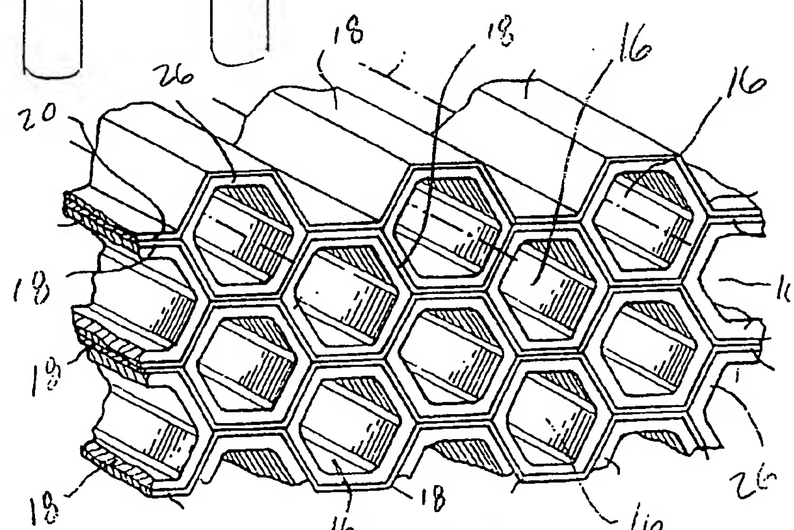


FIG. 5

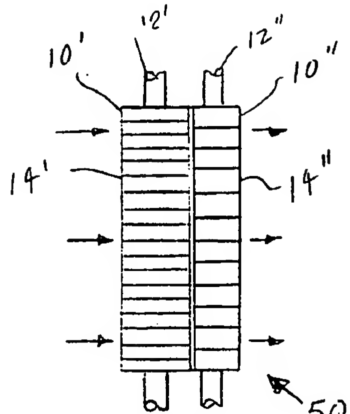


FIG. 6

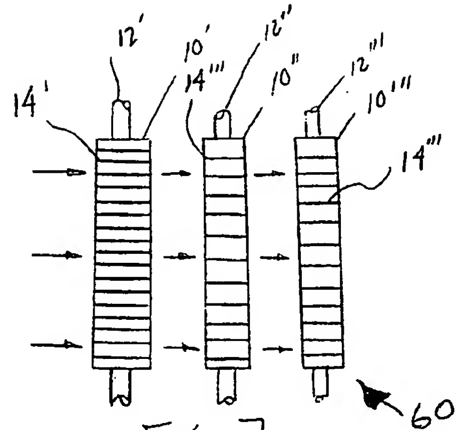


FIG. 7

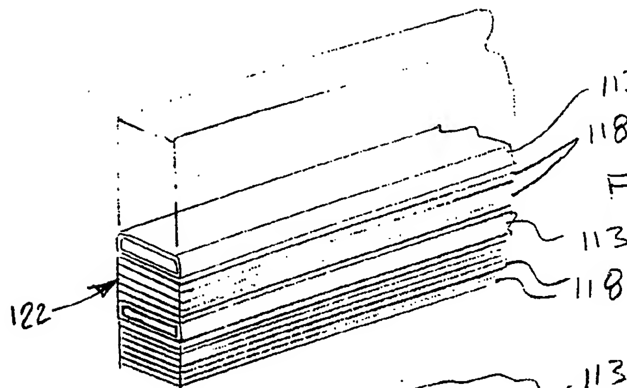


FIG. 8

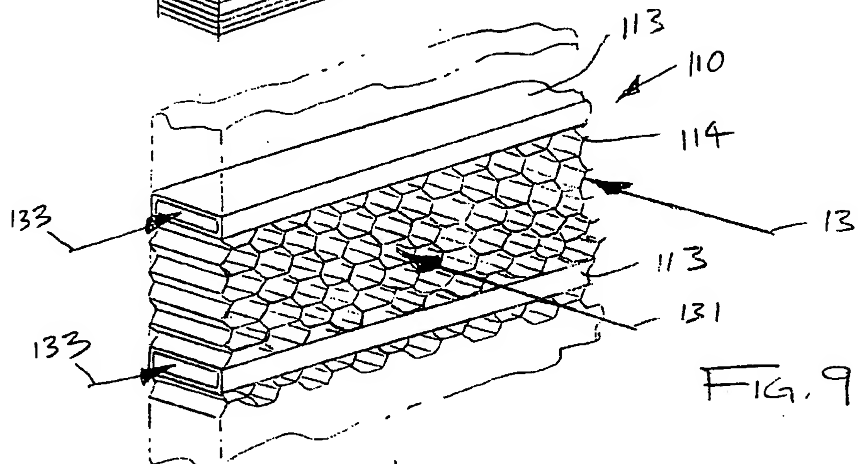


FIG. 9

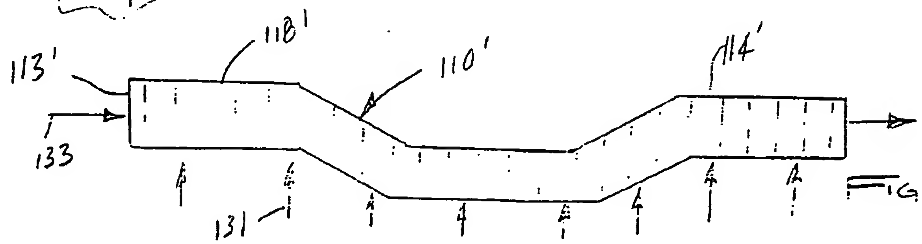


FIG. 10.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/11875

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :F28D 1/02, 1/04; F28F 1/20
US CL :165/151, 152, 181
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 165/151, 152, 181

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 674,845 E (AFFOUARD) 03 February 1930 (03.02.30), see figures 1-3, 7-8 and 13.	1-7, 10, 12-17 and 20-21.
Y,P	US 5,803,136 A (HARTSELL, JR) 08 September 1998, col. 3, lines 46-47.	8, 18 and 22.
Y	US 5,727,616 A (GROENKE) 17 March 1998, col. 1, lines 60-63.	9 and 19.
Y	US 5,476,140 A (LU) 19 December 1995, see figures 1 and 2.	11.

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 JULY 1999	19 OCT 1999

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